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Review

Microorganisms in Aquaculture Development

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Microbes found in aquaculture are usually from source water, feeds including augmented live foods. These microbes are found in the gills, intestine, muscles and on the surface of fish, shrimps, crustaceans and other aquatic organisms. Microorganisms in aquaculture play several roles including their use as live food, food supplements, probiotics, in pond aeration and in the purification of aquarium. As food, microbes provide the essential nutrients such as vitamins, enzymes, polyunsaturated fatty acids, amino acids, pigments and steroids; and serve as carbon and nitrogen sources. Microbial diversity in aquaculture depends largely on the quality (physicochemical properties) of the farm water and this has greatly influenced the growth of every aquaculture. Fungi, Bacteria, Protozoa, Helminthes and Microalgae are present in aquaculture, each performing its unique role in the ecosystem. While some are beneficial, others are not. They are used as probiotics to check the growth of some pathogenic microorganisms thereby reducing the incidence of aquarium diseases. Microbial live foods include Bacteria, Fungi, Microalgae and Protozoa. Microbes used as live food include lactic acid bacteria, Bacillus, Chlorella vulgaris, Saccharomyces and Aspergellus. These live foods have the advantage of small size, ease of digestion and ability to stimulate enzyme synthesis. Besides, microbes function in pond purification (biofilters) as well as its bioenergetic cycle. Microalgae, specifically aerate ponds through the release of oxygen during photosynthesis. The beneficial role of microbes has contributed immensely to the growth, development and sustainability of aquaculture.

Keywords: Aquaculture, Ecosystem, Live Feeds, Microorganisms Biofilters, Pathogens, Probiotcs, Producers.

INTRODUCTION

Aquarium microbiology refers to the population of microorganisms found in aquaculture such as in prawns, shrimps, mollusks, crustaceans, fish, and its associated environment. Microorganisms are found on the gills, intestinal tract, muscles and on the surface of these aquatic organisms. These microbes include bacteria, fungi, algae and protozoa. However, viruses and helminthes have also been isolated from aquaculture. They may be beneficial or non-beneficial to the host, but both play significant role in the quality of the aquaculture. The quality of water in the aquarium determines the diversity of its microbial population. These microbes have functioned as

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live food, probiotics and have helped in improving the quality of the aquarium water. The beneficial functions of microorganisms have contributed immensely to the growth and the development of fish in fish farms. However, some microorganisms are known pathogens and have caused diseases and possible death of their hosts. This paper will be limited to discourse on the important role of microorganisms in a fish farm.

MICROBIAL COMMUNITY ASSOCIATED WITH AQUACULTURE

Microbial diversity of fish farm depends to a large extent on its water quality. The water quality of a fish farm is determined by its physicochemical and biological properties. This is because water as home of most edible aquatic foods has not been given adequate attention until recently when the effects on aquatic foods started being noticed. (Ehiagbonare and Ogundiran 2010), stated that good water quality enhances optimal growth of aquatic organisms. Poor water quality is associated with heavy microbial load which consequently affect its microbial population and consequently the physic-chemical properties of the aquarium. Productivity, therefore, depends on the Physico-chemical characteristics of the farm's water body (Huct 1986). Some pathogenic Bacteria, helminthes and protozoa have been isolated from the gut of fresh water fish and crustaceans (Rappert and Müller 2005). According to (Robertson et al., 2000). *Carnobacteria, Lactobacillus, Leuconostoc, Streptococcus, Lactococcus* and *Vagococcus* have been isolated from fish and fish farm wastewater. Besides, diatoms (chlorella, *Chaetoceros* and *Skeletonema)* and yeasts genera (*Candida albicans, Cryptococcus neoformans*, Saccharomyces, e.t.c) are found in fish pond.

The sources of contamination are usually the aquatic environment, fish feeds used and the pond sediment; usually influence the microbial population of the aquatic organisms. Contamination of aquatic species may be from the environment become closely associated with and even colonizing the external surfaces (Sakata et al., 1980; Sakata et al., 1981). They may, also, be accumulation of the organisms at sites of damage (Sakata et al., 1980), such as missing scales or abrasions in fish (Sakata et al., 1981). The organisms may enter the mouth with water (Olafsen 2001) or food and pass through to the digestive tract (Sakata et al., 1981; Austin and Austin 2007).

MICROBIAL AQUACULTURE LIVE FOOD

These include bacteria, algae, and fungi.. These organisms have good nutritional value required for growth in aquaculture. They contain essential amino acids, protein and polysaccharides (Wang 2007). Bacteria is a rich source of exogenous enzymes, bacteria also helps in digestion and absorption process in the gut of aquaculture species According to (Wang 2007), and (Austin and Austin 2007), bacteria can be established in the gut of fish through food or through live food enrichment. Besides the use of bacteria, yeasts and microalgae have also been used as food supplements. Yeast can be directly used as a primary food source as a feed for zooplankton (Yamasaki and Hirata 1990), used in aquaculture.

Bacteria, yeasts and algae are important ingredients in artificial fish diets. The use of these microorganisms in aquaculture is not only because of its nutritional value but also small size for easy uptake at early stages of various aquatic animals. According to (Maruyama et al., 1997), micro algae serve as an essential food source for all stages of marine mollusks (clams, oysters, scallops), gastropods (abalone, conch), fish larvae (cod, halibut, tilapia) and shrimps (*Penaeus* sp). They can be fed to live food organisms (rotifers, copepods, cladocerans, brine shrimp etc.) (Maruyama et al., 1997).

Yeast can be directly used as a primary food source for many larvae but it is mainly used as a feed for zooplankton which is grown for use in larviculture. It is an important ingredient in artificial larval diets. Yeast has also been evaluated as supplement or replacement for algae in the feeding of post larval penaeid shrimps.

Being a rich source of exogenous enzymes, bacteria also helps in digestion and absorption process in the gut of larvae or food organisms by breaking down the larger particles into smaller ones.

Like bacteria, fungi and yeasts, microalgae in aquaculture both as feed and in nutrient cycle. Algae of major interest are chlorophyll bearing unicellular or multi-cellular plants. The multi-cellular groups exist in colonial or filamentous forms. The green algae serve as initial food producers and the first link in the aquatic food chain, both in freshwater and marine ecosystems. Mass culture of unicellular algae has becoming quite popular for aquaculture development (Brown et al., 1997).

The nutritional value of any algal species for a particular organism depends on its cell size, digestibility, production of toxic compounds, and biochemical composition (Brown et al., 1997). When cultured through to stationary phase, the proximate composition of microalgae can change significantly (Harrison et al., 1990). Polyunsaturated fatty acids derived from microalgae are known to be essential for various larvae (Sargent et al., 1997). There is variation in composition of vitamins between microalgae. Ascorbic acid shows the greatest variation, i.e. 1 to 16 mg g-1 dry weight (Brown and Miller 1992).

Microalgae are utilized as live feed for all growth stages in aquaculture food chains (Ferrari et al., 1993). Microalgae have an important role in aquaculture as a means of enriching zooplankton for feeding fish and other larvae and also help to aerate the pond. In addition to providing protein (essential amino acids) and energy, they provide other key nutrients such as vitamins, essential polyunsaturated fatty acids (PUFA), pigments and sterols, which are transferred through the food chain.

MICROBIAL PROBIOTICS/ EFFECTIVE MICROORGANISMS USED IN AQUACULTURE

Probiotics are Live microorganisms which when administered in adequate amounts confer a health benefit on the host [17]. *Lactobacillus* and *Bifidobacterium* genera have recently been used for out-competing pathogenic bacteria species from the gut of most aquaculture species. These microbes act as a barrier to gut pathogens by blocking their attachment to gut binding sites which is the first step of pathogenicity (Rengpipat et al., 1998). It can also play an important role in maintaining immune function. Besides, members of the natural aquatic microflora are effective at inhibiting fish pathogens (Okpokwasili and Alapiki 1990; Bérdy 2005). According to (Rengpipat et al., 1998), it is possible to manipulate the microflora of the developing fish by use of probiotics, i.e., live microbial food supplements, which may colonize the digestive tract for short or prolonged periods (Robertson et al., 2000). According to Robertson *et al.*(2000), these bacteria genera are mainly lactic acid bacteria. The lactic acid producing microorganisms have the ability to deliver antagonistic properties against undesirable pathogens by inhibiting the growth of such pathogens, competing for substrate and generating a non conducive acid environment (by changing the pH to more acidic values of 4 to 4.5). The antagonistic properties of some lactic acid producing microorganisms are partly due to their ability to produce other metabolites like enzymes, toxins, carbon dioxide, peroxides or antibiotics, also known as bacteriocines (Sakata et al., 1980; Sakata et al., 1981). The use of bacteria as a prophylactic measure is being encouraged in live food production to stabilize and promote aquaculture development through a microbiologically balanced system (Robertson et al., 2000). Probiotic materials have been used as food supplement in fish culture. The fish fed with such probiotics grew well without requiring drugs added (FEPA 1991; Hirata et al., 1998). Today commercial preparations of useful bacteria like *Bacillus subtilis*, *B. polyriyxa, B. negaterium* etc. are available in ready to use packs (Vazquez et al., 2005; Olafsen 2001). The species, *B. subtilis* is used for commercially production of secondary metabolites like antibiotics, enzymes, heterologous proteins, antigens and vaccines Olafsen 2001).

MICROBES IN POND WATER QUALITY ENHANCEMENT

Microbes as wastewater purifiers in Fish Farm

According to Ringo et al. (Ringo et al., 1996; Ringo et al., 2001), there are numerous microorganisms that are beneficial to fish by restoring water quality and creating a conducive culture environment. These microbes, strips off nitrogenous substances present in the culture environment thereby improving the water quality. The extracellular enzymes produced by these microorganisms degrade organic accumulated debris from shrimp/fish cultures inducing ponds bioremediation and consequently the prevention of viral and bacterial diseases (Ringo et al., 2001; Sorokulova 2013). The bacteria provide the waste treatment by removing pollutants. Fish's waste (toxic ammonia compounds) excreted into the water and uneaten fish feed particles. This biofilter is the site where beneficial bacteria remove (detoxify) fish excretory products, primarily ammonia (Sorokulova 2013).

Microbial pond Aeration

Besides toxic ammonia, carbon dioxide concentration takes place in intensive fish production systems. As carbon dioxide increases, the pH of the water decreases, and fish respiration is affected (Gatesoupe 1999; Burgess et al., 2001). Carbon dioxide levels should be maintained at levels less than 30 mg/l for good fish growth (Brown et al., 1997). Some carbon dioxide is beneficial since it reduces pH and mitigates ammonia toxicity. Carbon dioxide removal can be accomplished by the photosynthetic activities of aquatic green algae. These algae utilize carbon dioxide in the synthesis of plant carbohydrate and in turn release oxygen into the aquatic system. The release of oxygen ensures continued aerobic state of the pond and maintains healthy state of fish in the aquarium.

MICROBIAL PATHOGENS OF FISH

Microorganisms are not only beneficial in aquaculture; there are some with negative impact on fish and other aquarium species. Although this paper is not interested in this group of microbes, there is the need to discuss a few of them. This is because their presence in aquaculture prompts the need for use of probiotics and some other antimicrobial agent due to their ability to cause diseases. As many pathogens naturally occur in aquatic environments, all forms of aquaculture are prone to disease outbreaks which are largely determined by host susceptibility (Ringo et al., 1996; Ringo et al., 2001). Also, physiological stress contributes to diseases and increase mortality in aquaculture. It leads to decreased disease resistance, impaired reproduction and reduced growth. It could also lead to intestinal microbiota disorders which decrease the level of beneficial micro-organism and thereby giving room to invasion from bacteria disease; a significant cause of mortality in most fish hatcheries (Ringo et al., 2001; Del Rio Rodriguez et al., 1997), and high mortalities especially during transition from the yolk sac to the first feeding stage of development [25,30]. Bacteria, fungi, protozoa and helminthes are known pathogens of fish. Bacteria genera such as *Aeromonas, Vibrio, Staphylococcus, Corynobacteria, Pseudomonas, Acinetobacter, Enterobacter, Escherichia, Klebsiella, Proteus, Serratia,* and fungal genus Cryptococcus, protozoan(*Ichthyophthirius multifiliis*) and helminthes (*Huffmanela huffmani and Clinostomum marginatum)* have been incriminated in fresh water fish diseases (Rappert and Müller 2005; Ringo et al., 1996; Del Rio Rodriguez et al., 1997), and are described as common pathogens in fish farm

SUMMARY AND CONCLUSION

Microorganisms have been used to improve the growth and development of aquaculture business in Nigeria. They are used as food by zooplanktons which in turn serve as food for crustaceans and fish. They also function as food supplements for enzymes, amino acids and vitamins needed for growth and development of these aquatic lives. Microorganisms occupy central position in the bioenergetic cycle in aquaculture. They have been used in degradation of wastes generated by these aquatic organisms, utilizing them as carbon and nitrogen sources, and detoxifying some generated toxic wastes. Consequently, they purify the aquarium wastewater by acting as biofilters. Finally, probiotic activities of microorganisms have earned them good use in aquaculture and this has helped in preventing and controlling aquatic life diseases. Although they have these beneficial qualities, some have also been associated with fish diseases. Since microbes are organic, their use in aquaculture creates a more ecofriendly environment and, therefore, must be encouraged.

REFERENCES

Al-Harbbi AH, Uddin MN (2008). Aerobic bacteria flora of common carp (*Cyprinus carpio* L) cultured in earthen ponds in Saudi Arabia. *Journal of Applied Aquaculture*. 20(2):108–119.

Austin B, Austin DA (2007). Bacterial fish pathogens: diseases in farmed and wild fish. Chichester, Ellis Horwood., p364.

Bérdy J (2005). Bioactive microbial metabolites. J Antibiot (Tokyo) 58: 1-26.

Brown MR, Jeffrey SW, Volkman JK, Dunstan GA (1997). Nutritional properties of microalgae for mariculture. *Aquaculture*, 151: 315-331.

Brown MR, Miller KA (1992). The ascorbic acid content of eleven species of microalgae used in mariculture. *Journal of Applied Phycology*, 4: 205-215.

Burgess JE, Parson S, Stuetz R (2001). Developments in odour control and waste gas treatment biotechnology: a review. *Biotechnology Advances* **19**: 35–63.

Del Rio Rodriguez RE, Inglis V, Millar SD (1997). Survival of *Escherichia coli* in the intestine of fish. *Aquacult. Res.* **28**, 257-264.

Ehiagbonare JE, Ogundiran YO (2010). Physico-chemical analysis of fish pond waters in Okada and its environs, Nigeria. African J. Biotech., 9(36), 5922-5928.

FEPA (1991). Guidelines and Standards for environmental Pollution Control. Fed. Environ. Prot. Agency, 27:.20.

Ferrari E, Jarnagin AS, Schmidt BF (1993). Commercial production of extracellular enzymes. In: Sonenshein AL, Hoch JA, Losick R (Eds.), *Bacillus* subtilis and Other Gram-Positive Bacteria. American Society for Microbiology, Washington, DC, pp. 917-937.

Gatesoupe FJ (1999). The use of probiotics in aquaculture. Aquaculture 180:147-165.

Harrison PJ, Thompson PA, Calderwood GS (1990). Effects of nutrient and light limitation on the biochemical composition of phytoplankton. *Journal of Applied Phycology*, 2: 45-56.

Hirata H, Murata O, Yamada S, Ishitani H, Wachi M (1998). Probiotic culture of the rotifer *Brachionus plicatilis*. *Hydrobiologia*, 387/388: 495-498.

Huct M (1986). Textbook of fish culture 2nd Edn., Fish News Book Ltd., England. Vide Study on the physicochemical properties of water of Mouri River, Khulna Bangladesh, Pak. J. Biol. Sci.,10(5), 710-717.

Maruyama I, Nakao T, Shigeno I, Ando Y, Hirayama K (1997). Application of unicellular algae *Chlorella vulgaris* for the mass culture of marine rotifer *Brachionus*. *Hydrobiologia*, 358:133-138.

Okpokwasili GC, Alapiki AM (1990). Bacterial flora associated with a Nigerian freshwater fish culture. *J. Aquacult. Trop*. 5:87–90.

Olafsen JA (2001). Interaction between fish larvae and bacteria in marine aquaculture. *Aquaculture*. 200:223–247.

Rappert S, Müller R (2005). Microbial degradation of selected odourous substances. *Waste Menagement* 25: 940–954.

Rengpipat S, Phianphak W, Piyatiratitivorakul S, Menasvetac P (1998). Effects of a probiotic bacterium on black tiger shrimp Penaeus monodon survival and growth. Aquaculture 167: 301-313.

Ringo E, Birkbeck TH, Munro PD, Vadstein O, Hjelmeland K (1996). The effect of early exposure to *Vibrio pelagius* on the aerobic bacterial flora of *Scophthalmus maximum* (L). *Journal of Applied Bacteriology.* 81:207-211.

Ringo E, Lodemel JB, Myklebust R, Kaino T, Mayhew TM, Olsen RE (2001). Epithelium associated bacteria in the gastrointestinal tract of Arctic charr (*Salvelinus alpinus* L.). An electron microscopical study. *J. Appl. Microbiol.* 90, 294-300.

Robertson PAW, O-Dowd C, Burrells C, Williams P, Austin B (2000). Use of *Carnobacterium* sp. as a probiotic for Atlantic salmon (*Salmo salar* L.) and rainbow trout (*Oncorhynchus mykiss*, Walbaum). *Aquaculture* 185, 235-243.

Sakata T, Okabayashi J, Kakimoto D (1980). Variations in the intestinal microflora of *Tilapia* reared in fresh and seawater. *Bull. Jpn. Soc. Sci. Fish.*46: 313-317.

Sakata T, Sugita H, Mitsuoka T, Kakimoto D, Kadota H (1981). Microflora in the gastrointestinal tracts of fresh-water fish. 11. Characteristics of obligate anaerobic-bacteria in the intestines of fresh-water fish. *Bull. Jpn. Soc. Sci. Fish.* 47, 421-427.

Sargent JR, McEvoy LA, Bell JG (1997). Requirements, presentation and sources of polyunsaturated fatty acids in marine fish larval feeds. *Aquaculture*, 155: 117-127.

Sorokulova I (2013). Modern status and perspectives of Bacillus bacteria as probiotics. J Prob *Health*, 1: 1-5.

Vazquez JA, Gonzalez MP, Murado MA (2005). Effects of lactic acid bacteria cultures on pathogenic microbiota from fish. *Aquaculture*, 245: 149–161.
Wang YB (2007). Effect of probiotics on growth performance and digestive enzyme activity of the shrimp *Penaeus vannamei*. *Aquaculture*, 269: 259–264.
Yamasaki S, Hirata H (1990). Relationship between food consumption and metabolism of rotifer *Brachionus plicatilis*. *Nippon Suisan Gakkaishi*, 56: 591–594.